experience, he is not adaptable; he moves in much the same groove as did his ancestors of a million years ago.

Higher than the caterpillar in the animal scale, the power of growing mentally in response to functional activity is clearly in being. Animals are able to recognise mates and offspring, and the latter are able to recognise their guardians. Family life begins. The offspring, more or less helpless at birth, but protected by their guardians, have ability and opportunity to develop physically and mentally in response to functional activity until they are able to fend for themselves. They begin to think, they become adaptable. This evolution culminates in man, who is born so helpless that he cannot even seek the breast, but who learns so enormously that he becomes rational. Reason is merely intelligence *in excelsis*. A vast and complex store of experience then lights a complex, and perhaps distant, future. Compare three human individuals—an idiot, a newly born baby, and a normal man. The idiot cannot learn, and has not learned; the baby can learn, but has not learned; the normal man can learn, and has learned. There in a nutshell is all the mental difference between them, except that the baby has not yet developed a few instincts. The idiot has these instincts, but, probably because he has lacked some hormone, has reverted by mutation (himself or by some progenitor) to an enormously remote ancestry in which the power of learning was defective. One day I think we shall cure idiocy by the injection of the proper glandular extract. Compare a man with a dog: how enormously greater is the human power of learning, and, therefore, of thinking. Compare him with a house-fly: the fly settles on the hand; we strike at it; impelled by instinct, it shoots away; a moment after, having ceased to "bear in mind," it is back again, unmindful of a danger the recollection of which would set a man shuddering for years. We are able to domesticate animals only when they have the capacity to learn to tolerate, to obey, and, when the intelligence is very great (*e.g.* dog), even to love us. Savage man is so intelligent that he has invented language by means of which he is able to hand on the accumulated traditions of generations. Civilised man differs from him in that he has invented aids to his powers of remembering (*e.g.* books of reference), of thinking (*e.g.* mathematics), and of doing (*e.g.* tools). The retrogression of instinct and its replacement by intelligence is well illustrated by maternal care among brutes and men. Among the former it is instinctive, but women have to learn how to tend their young. Again, while insects walk instinctively, men learn. Among the higher animals the number of offspring is controlled by the number which can be protected and taught.

This or that naturalist may disagree as to this or that detail of what I have written about mind, but with the main argument I think all must agree. Already, in practice if not in theory, actions which are not initiated by the will are called reflex; those which are initiated by the will, but in which learning plays no part, are called instinctive; while those which are both initiated by the will and result from learning are called intelligent. As to the evolution of the potentiality of developing in response to use, the truth is glaringly obvious. Even a schoolboy knows that he can teach a beetle nothing, a cat a little, a dog more, and a child much. But all this is incompatible with Lamarck's first law, which has met with such general acceptance. As regards body, the evolution may be more difficult to trace. At any rate, it has not been studied. But as regards mind it is as clear as sunlight. Plainly, an animal is intelligent in proportion as it is able to profit from experience; man's reason and intellect depend wholly on his power of learning; and, as well as I can judge, whenever an animal is capable of learning it is also capable of developing physically in a corresponding degree in response to the stimulus of use.

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Pencil Markings in the Bodleian Library.

In a former communication (Nature, 1920, vol. 105, p. 12) I described a method of distinguishing microscopically between the markings made upon paper with different kinds of pencils, and gave some account of the characteristics of early pencil writings in the British Museum.

I am now indebted to the Librarian of the Bodleian Library and to Dr. Craster for their kindness in giving me facilities for studying similar early specimens of pencil writing in that library.

In Schönemann's work on the examination of early MSS. ("Versuch eines Systems der Diplomatik," 1818, vol. ii. p. 108) it is stated that the ruled lines in various documents of the eleventh and twelfth centuries are in a graphite pigment. Referring to this statement I pointed out (*loc. cit.*) that, since graphite was only discovered in 1560, it was obvious that Schönemann must have mistaken ordinary metallic lead for graphite.

The historical basis for my criticism is to be found in Gesner's "De Rerum Fossilium Lapidum et Gemmarum Genere," 1565, vol. ii. p. 105, and in Beckmann's "Beiträge zur Geschichte der Erfindungen" (1780). It appears, however, that graphite must have been known long before that time, for, after reading my communication, Prof. Flinders Petrie informed me that he had discovered a lump of graphite at Ghorub, which must have dated back to a period between 1500 and 1200 B.C., although there was no evidence that graphite was ever used as a pigment in ancient Egypt.

This unique specimen of graphite, a portion of which Prof. Flinders Petrie has kindly given me for examination, is a decidedly coarse, impure mineral, containing only 39·4 per cent. of carbon, and the amount of silicious impurities present is plainly indicated by the pronounced irregular striations in the markings on paper.

This proof that graphite was known ages before its reputed discovery in 1560 in the Borrowdale mine, gives an added interest to the examination of the earliest pencil markings available in this country.

The earliest known instance of pencil marking in the Bodleian is a vellum MS. Commentary on the Book of Job of the thirteenth century (Auct. D. iii. 14). This has vertical lines, ruled with a stylus down the sides of the writing, and the microscope shows that the pigment of these is lead or other metal.

In the "Opuscula Varia SS. Augustini et Bernardi" of the thirteenth and fourteenth centuries (Hatton MS. 102), the ruled lines surrounding the text are in a red ink in some of the MSS., whilst in others they are in a metallic pigment. In another Hatton MS. (No. 107) of the fourteenth century, no pencil markings are present, the ruled lines at the side and the annotations being in a pale brown ink.

The "Opera Johannis Dastyn" of 1590 (Bodl. MS. 485) is written in ink, and shows pencil strokes at the side written in graphite, but there is no evidence that these markings were contemporaneous with the body of the MS.

An Italian MS. on paper, "Geomantia" (Digby MS. 133), written in ink prior to 1634, shows fine ruled lines at the side in a brilliant metallic pigment;

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and the annotations in a Hebrew MS. "Jad Chazaka" (Poc. 235) of about 1650 are also in lead or a lead alloy.

The notebook of the Swiss scholar Casaubon, (Casaubon MS. 61), written about 1613, is particularly interesting. The leaves of the book are of thick horn and are covered on each side with minute writing, which is in a metallic pigment, showing much finer spicules than is usual in the writing done with a metal style. It resembles the pigment used in the drawings of the Stowe MS. "Arms of Ancient Nobilitie" of the early seventeenth century (British Museum).

A series of almanacs interleaved and containing Anthony Wood's Diary from 1676 to 1685 (Wood's Diaries 20-29, 742), shows ruled lines in a metallic pigment, while the entries in the diaries are either in ink or, less frequently, in pencil. Referring to the latter entries, the Rev. Andrew Clark remarked ("Life and Times of Anthony Wood," I. 3 Oxf. Hist. Soc., 1891): "Wood's pencil, I assume, was not graphite, but actual lead. It has left a faint mark, almost illegible, except for the indentation of the paper." Microscopical examination of these entries down to 1685 showed that this assumption was correct, none of the writing having the characteristics of graphite.

At a later date, however, Wood appears to have had a graphite pencil. "A Collection of Poems on Affairs of State," London, 1689 (Wood, 382) has a note on its flyleaf in the writing of Wood: "Bought at Oxon. 26 Feb. 1688." (The discrepancy between the dates is explained by the use of the old style for one of them.) This writing has the appearance of ordinary graphite, the masses of black pigment being uniformly distributed, and none of the particles showing the lustre or striation of lead or its alloys.

With the very doubtful exception of the markings in the MS. of Johannis Dastyn (*supra*), this is the earliest writing in graphite pencil noted in the Bodleian Library.

It will be recalled that the earliest graphite writing found in the British Museum was in two Notebooks of Sir Thomas Cotton, one of about 1630-1640 and the other 1640-1644.

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Haloes and Earth-History: A New Radioactive Element.

IN the Archæan black mica of Ytterby, very small, colourless, spherical, halo-like forms occur. The mica is, as it were, bleached within these halo-spheres. Many show a central opaque particle or nucleus. In the case of others it is difficult to be sure of the presence of a nucleus, or it may take the form of a limpid refracting particle. The optical appearances suggest that in these spheres the refractive index of the mica has been raised.

They are very small. A cluster of these minute haloes, amounting to many hundreds, presents with a low power the appearance of a starry sky. The average diameter appears to be 0·01 mm., no allowance being made for the nucleus. The greater number are remarkably uniform in diameter. Thus, readings of 23 of these haloes, taken at random, range from 50 to 59 scale divisions of the micrometer. A few larger ones are present, but, as in most cases their greater size is directly referable to an aggregation of nuclear particles occupying a large central volume, it seems safe to conclude that these limpid spheres are in reality of one size only.

The mica flake in which this cluster occurs is 0·018 mm. thick, or perhaps a little less. The minute spheres are located at various depths in the mica—some below the surface, some more or less truncated. Many are sharp and easily measured; others, as would be expected, are diffuse upon the edge.

I have been for some years aware of the existence of these haloes—since a period before the war—but, during the occupation of my laboratory by troops in 1916, among other things lost was the specimen of Ytterby mica from which my slides were obtained. A few other samples of this mica did not appear to contain them. Nor could I form any probable theory to account for them. Their uniform size convinced me that they were radioactive. The hypothesis that they might be due to slow β-radiation had really nothing to support it: no similar effect having been found in any other mica. Later I concluded that they must be reversed haloes such as I found in the Devonian mica of Co. Carlow. There were other appearances to support this view. Thus in the very similar Archæan mica from Arendal, bleached uranium haloes in various stages were found. Again, in both the Ytterby and Arendal mica, semi-bleached bands occur having a centrally placed line of what are probably radioactive particles disposed like a central moraine on a glacier. But with these appearances of reversal were vigorous haloes in all stages of development.

Recently, Dr. Prior was so good as to send me some flakes of Ytterby mica. In them I found all the appearances described above, including a few of the minute bleached halo-spheres.

The idea that this bleaching of the Archæan micas might be due to former high temperature conditions led to a test of the behaviour of the Carlow mica at different temperatures. It was found that a halo-rich specimen of this mica after an hour's exposure to a temperature of about 730° C. had acquired many of the characters of the Archæan micas. Most of the haloes had disappeared, and some had left a bleached area giving quite characteristic readings. Bleached bands, also, had taken the place of linear radioactive staining; and the originating radioactive particles were exposed to view forming a central line.

There is, I think, no doubt that these (and other) appearances show that the Ytterby and Arendal Archæan micas were at some remote period subjected to a temperature probably not much exceeding 700° C. during which a prior-existing crop of haloes were obliterated or reversed, and that, therefore, the existing haloes are a second crop which originated from the same nuclei when the thermal conditions permitted their development. This history has a good deal that is fortuitous connected with it. Some three hundred additional degrees of temperature would have reduced the mica to a slag.

But what is to be inferred as to the nature of the minute halo-spheres? A chance find seems to bear upon their origin.

In the mica of Arendal uranium haloes are fairly abundant; they occur in every stage of development. Within some of the earliest rings having radial dimensions reading from 0·0150 to 0·0160 (corresponding to rings which in Devonian mica read 0·0145) a very minute ring is sometimes seen. It is a difficult object and needs good lighting and good sight to detect. This ring surrounds the point-like nucleus with perfect centricity, an intervening band of unstained mica being apparent. The radius of this ring has been read from 0·0049 to 0·0057. The effect of the nuclear dimensions on a ring so small

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